TITANIUM & THE NUCLEAR RENAISSANCE
A POLITICAL & PRACTICAL UPDATE

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ABSTRACT

Notwithstanding the current world economic downturn coupled with spiraling oil prices, the global demand for energy continues unabated. It is also clear the continued use of fossil fuels for electric power generation remains the bane of the PowerGen industry. Global warming, green power, carbon capture and sequestration, emission cap & trade and other political agendas touting global warming principals continue unabated.

In some circles, scientific consensus indicates that rising atmospheric concentrations of carbon dioxide and other greenhouse gases are changing the earth’s climate. The ultimate objective of the Gore Principal, the United Nations Framework Convention on Climate Change (UNFCCC) and other pundits is to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference within the climate system. Fact or fiction, this concept appears to be the main driver for demise of fossil fuels and the tacit acceptance of nuclear energy by the prior foes – conceivably a choice of the lesser of two evils.

Unfortunately, the Electric Power Generation Industry will not know if a full nuclear renaissance is underway for several more years. Assuming this energy source conceives and bears the gestated fruit of the renaissance, the next several years will indeed, be telling. However an immediate and positive sign lies in the action taken by several utilities and NSSS suppliers in ordering long lead time items recognizing that both from a political and purely practical position, the first in line will reap the rewards.
Where and how does all this rhetoric impact the titanium industry? Globally, the solutions remain classically technical. In the U.S., prophetic answers unfortunately lie in a future political agenda. This paper charts a course through the practical and political landscape of each and suggests a revised impact on the world titanium industry.

BACKGROUND & REVIEW

Currently, there are 440 nuclear power reactors around the world with 104 in the U.S. producing some 11% of the world’s power generation needs and 20% in the US (See Figure 1). Many of these reactors are nearing the end of their useful life. As a result, capacity uprates emerge as one of the remaining viable revenue generators in this nuclear cash cow market (Figure 2).

![Figure 1: Current U.S. Fuel Mix Breakdown](image1)

![Figure 2: Capacity Uprates](image2)

WORLD & DOMESTIC ENERGY MARKETS

With world electrical demand advancing annually at 2-3% levels (Figure 4), it is worthwhile to take a quick snapshot of the overall energy markets and specifically, the status of commercial nuclear power on a global basis. Figure 3 provides a color-coded status review of areas of the world that employ nuclear power, are building new plants, considering new plants, employ stable environments or have no plants whatsoever. It is noteworthy that much of the populated world
shares the existing 440 unit fleet of power reactors while less populated areas are nearly devoid of this generation source.

**Figure 3**
Global Commercial Nuclear Power

**Figure 4**
Energy Markets Growth Analysis

**ADVANCED REACTOR DESIGNS**

To compliment the significant availability factor advances made by the existing nuclear fleets, new, Generation II reactor designs have been heralded as dramatically advancing the economics and safety of the package. Indeed, this new generation of light water reactors offers a highly economical and more modular package, enhanced safety, purported minimal waste and resistance to fuel proliferation. Currently, the U.S. NRC has certified four (4) reactor designs. They include:
Advanced Boiling-Water Reactor (ABWR) GE/Toshiba (1300 MW)
System 80 Westinghouse (1300 MW)
AP 600 Westinghouse (600 MW)
AP1000 Westinghouse (1000 MW)

Other reactor designs are currently being evaluated and hold promise for NRC and/or world certification as well. They include:

- General Electric ESBWR 1390 MW
- Atomic Energy of Canada (AECL) 700 MW
- Framatome ANP (EPR) 1600 MW
- International Reactor Innovative & Secure (IRIS) 335 – 1000 MW
- Pebble Bed Modular Reactor (PBMR) 165 MW
- Gas Turbine-Modular Helium Reactor (GT-MHR)

THE REGULATORY ENVIRONMENT

The year 2008 was christened “the breakthrough year” of the purported “nuclear renaissance”. Unfortunately, it would appear that much of this anticipated event did not occur. Yes, the NRC hired 400 new employees to process the anticipated deluge of COL’s or Combined Construction and Operating Licenses. From 2008 through 2011, the NRC was expected to process 29 COL’s. In actuality, 3 were processed or are in process in 2007 and 6 - 7 are scheduled for 2008.

Yes, the U.S. NRC (Nuclear Regulatory Commission) and other world regulatory bodies have made the road to licensing somewhat less bumpy than in the past shortening the path for prospective buyers. And yes, the U.S. Energy Policy Act (Bush Administration) financial umbrellas were encouraging but did not provide the needed urging to “belly up to the bar” with vigor.

Figure 5
U.S. Energy Policy Act Incentives

- Protection from cost overruns
- 1.6¢/Kw hour production tax credit
- Federal loan guarantees

Given the current political climate in Washington, all these may prove to be an illusion should partisan policies prevail. However, in spite of all of the above rhetoric, the world is either building, planning or proposing some 160 new power reactors over the next 15 years (See Figure 6).

A second snapshot identified as Figure 7 highlights the current state of License Applications for the commercial nuclear reactor business in the U.S. It is noteworthy that as of June, 2008, four (4) applications have been submitted to the NRC and are under current review. An additional 5 have been submitted in 2008 and additional 20 remain on the sidelines undecided.
### Energy Markets Growth Analysis (Updated)

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THE POLITICAL ENVIRONMENT

The predicted renaissance of the nuclear power industry faces a stiff wind indeed which will clearly carry the residue of partisan politics. Forecasters are bracing for a departure from the nuke-friendly, albeit grossly inactive Bush Administration DOE & NRC policies to the de facto and much heralded and inevitable political changes scheduled for January 09'.
To euphemistically acquaint the reader with the current presidential candidate’s political position on Nuclear Energy, here is a short quiz matching the presumptive U.S. presidential candidates - Obama vs. McCain.

Quotation No. 1: “I think nuclear power has to be part of our energy solutions.”
Quotation No. 2: “I don’t think we can take nuclear power off the table.”
Quotation No. 3: “I believe we have to go back to nuclear power.”

“You did it…….You did it.” A classic line proclaimed by Jimmy Cagney in the film Mr. Roberts says it all. In this case, both did it! Echoing the complaint many years ago that there wasn’t “a dimes worth of difference” between candidates, today, accounting for inflation, it’s safe to say that a quarter will suffice.

However, having duly noted the apparent candidate parity, a winning Democratic ticket will usher in change that will clearly create a non-friendly nuke environment in Washington. Here are several reasons for this statement.

1. Both Obama and H. Reid (Nevada) have issued death threats against the final design certification for the Yucca Mountain dry storage facility. Even though the NRC, after 12 years of study, has a final review and recommendation in hand, the November electoral votes for Nevada will predictably result in outright cancellation of this facility.

2. Gregory Jaczko appears to be the front runner and presumptive appointee to the position of NRC Commissioner no matter what Administration takes power. This twice rejected Chair candidate is clearly anti-nuke and will certainly act as an affront to progress in the COL application process.

3. Partisan, pro-nuclear politicians are losing clout in Washington. Senator Pete Domenici is stepping down because of age and health; Senator Larry Craig’s career is “in the toilet” with no pun intended and Senator Craig Thomas has died.

IBM coined a phrase some years ago to confuse their competition. The term FUD was used to instill fear, uncertainty and doubt. I will predict this FUD concept will emerge as the continuing bane and challenge of the nuclear industry.

WHY NUCLEAR POWER?

The prime consideration in expanding nuclear power can be concisely stated. The first reason is economically compelling as this energy source has raised the reliability bar and lowered the cost of service to the customer. As noted earlier, the nuclear capacity factor in the U.S. has reached all time highs (90%+) and electrical production cost, in most plants, is below 2 cents/kWh – far below the cost of competing fuels. Industry consolidation combined with efficiencies of scale and lowered costs over the past 10 years has led to excellent financial returns. In addition, CERA has also cited high fossil fuel prices and energy security as adding to the possible expansion of nuclear power. Because of these factors, utilities are compelled to consider the possibility of adding more nukes.

On the emotional flip-side, the postulated Al Gore principal of global warming along with the given administrative change in the White house applies. Fact or fiction, the Gore principal appears to be the main driver for the tacit acceptance of nuclear energy by the prior foes. The incoming White House Administration will be in position to play the proverbial nuclear wild card on how or
when nuclear power will be supported or trumped.

TITANIUM & NUCLEAR POWER

Titanium has clearly emerged as the material of choice for the nuclear power plant condenser and ancillary heat exchanger tube material. A high percentage of existing/operating nuclear units, where operating licenses have been extended an additional 20 years, have recognized the benefits of titanium and replaced their existing condenser with redesigned modular units incorporating Gr. 2 titanium. Fast forward to today where design and materials engineers are incorporating this proven material into Generation II nuclear units fully anticipating the titanium condenser tube material to last for the operational life of the unit. This is not unexpected as currently, there are several operating fossil units where the titanium-tube condensers are either approaching or have broken through the trouble-free 40 year life barrier. It is the opinion of this author that competing materials cannot claim corrosion immunity in these hostile environments offered by Gr. 2 titanium.

Given the 40 to 60 year anticipated material life expectancy, only rhetoric abounds when discussing materials of constitution for surface condensers and BOP heat exchangers other than titanium.

MATERIAL FORECAST

Currently there are some 160+ reactors proposed to come on line over the next 15 - 20 years. Twenty-nine (29) in the US have either submitted their applications to the NRC or intend to do so shortly. Having noted the above, certain conservative assumptions can be made in terms of numbers of plants that will actually be built, plant MW size, construction windows, condenser design, construction materials, etc. It has been noted earlier in this paper that to date, most specifications for condenser and BOP exchanger materials specify titanium as the tube material of choice. This recommendation includes a mix of solid or kinetically bonded Gr. 1 for tubesheets and the more significant amounts of Gr. 2 material tubing use. Here are this author’s usage estimates. At current levels, actual procurement could begin as early as 2010 – 2012.

<table>
<thead>
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<th>No Reactors 10-15 Year Build Rate</th>
<th>No Reactors Using Titanium Materials</th>
<th>Total Tonnage Over 10 - 15 Year Period</th>
<th>Total Value (USD) over 10 – 15 Years</th>
<th>Annual Ti Purchases Begin 2010</th>
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<tr>
<td>160 +</td>
<td>≈ 100 +</td>
<td>38,000</td>
<td>$1.9 x 10^8</td>
<td>≈ 4000 tons/yr</td>
</tr>
</tbody>
</table>

Note: Compare this estimate vs. an ITA Conference world forecast shipment of ≈ 110,000 2010. Data may be adjusted based on reduced aero build rates.

CONCLUSION

In support of their preeminent position in the marketplace, Microsoft Corporation expends, as one would expect, a significant portion of their revenues for Research & Development. Return on this investment is expected to produce significant future revenue for this industry giant. Conversely, one would think that the U.S. Department of Energy (DOE) would have similar, if not expanded R&D expenditure goals. These goals may not be revenue-based but would provide practical, industry-wide guidelines. Unfortunately, this is not the case as demonstrated by the below figure. Given this disparity, it is clear there is a continuum of misguided priorities within not only this current administration but past administrations (Figure 7) has placed this organization in a political and bureaucratic straight jacket.

Here are additional fact or fiction considerations that have made the direct, line-of-site march to embracing energy source a little less clear.
At the risk of repetition and as noted earlier in this paper, the world is either building, planning or proposing some 160 new power reactors over the next 15 years.

By 2100, the world population is expected to be 50% larger then present.

New reactors operate with proven technology.

Spent fuel storage remains on open issue.

Carbon caps and CO₂ capture & sequestration on coal has clearly diminished its luster.

High natural gas prices are already affecting the use off CCGT (gas-fired).

The cost of a new nuke was initially forecast in the $3,500/kW range – more than 3X a comparable coal-fired plant and 5-7X more than a comparable CCGT (gas-fired) plant. Current estimates have escalated to $5000 - $6000/kW.

From COL application to turbine roll, a construction interval of 10-12 years is not unrealistic.

Both government and the financial community will have to fiscally embrace both merchant provider and investor-owned utility in assistance in cost recovery. Partnering may become a requisite.

Cost and availability of nuclear fuel is a consideration but not a constraint.

The lawyers will win.

This second sorting of the chaff from the wheat suggests that the Electric Power Generation Industry will not know if a nuclear renaissance is underway for probably one more year.
Assuming this energy source conceives and bears the gestated fruit of the renaissance, the run-up in commitments will be swift and significant. However an immediate and positive sign lies in the action taken by several utilities in ordering long lead time items recognizing that both from a political and purely practical position, the first in line will reap the rewards. In addition, and at this point in time, 19 U.S. utility/consortiums have committed to at least the application process for 29 reactors with nine currently in review by the NRC – some 160 on a world-wide basis. Nuclear power isn’t a perfect answer but safely managed and regulated, it needs to be a bigger part of the world’s energy future.

ACKNOWLEDGMENTS

2. CERA – Cambridge Energy Research Associate
5. EIA – Energy Information Administration
6. Forty (40) years of PowerGen experience by the author
7. MATERIAL FORECAST represented by the author should be considered as an estimate only.
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Las Vegas, Nevada USA
A growing need for additional electric capacity...

- Electricity demand in the U.S. in 2030 will be 45% greater than today
- To maintain current electric fuel supply mix would mean building

- **50 Nuclear reactors (1,000 MW/ea)**
  - **93 Renewables (100 MW/ea)**
  - **279 Natural gas plants (400 MW/ea)**
  - **261 Coal-fired plants (600 MW/ea)**
Electrical Demand & Fuel Usage Forecast

Ref: Energy Information Administration
UNITED STATES – 104 Nukes

400+ WORLD
NUCLEAR
POWER
MAKEUP
~ 11%

Source: Energy Information Administration
Anticipated Capacity Upgrades at U.S. Nuclear Plants

This “Lost” Power Needs To Be Replaced
WHY NUCLEAR POWER?
Environmentalists and other global warming advocates are successfully lobbying their political agendas for emission caps, carbon sequestration, N0x and S0x and other greenhouse gas limits.

Continued use of fossil fuels for electric power generation has recently emerged as the bane of the industry.

Green Power is being championed as the new fuel de jour kid on the block.
Combin
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during the Enron “gas bubble” era are at the mercy of unstable fuel prices.

Combined cycle gas turbine (CCGT) units, popularized during the Enron “gas bubble” era are at the mercy of unstable fuel prices.

These efforts have resulted in the outright cancellation, delay or unit reductions of new coal-fired plants.

Wind, biomass, hydro, photovoltaic and other renewables continue to produce an increased percentage of the power base but total contribution remains costly, inefficient and pitifully low.

“I propose 100% renewable power And a zero carbon Footprint within 10 years !!!”
Enter The Nuclear Renaissance…..
REAL REASONS FOR NUCLEAR POWER?

Economically Compelling - Lowest generated cost among competing fuels @ < 2 cents/KWh
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**E**conomically Compelling - Lowest generated cost among competing fuels @ < 2 cents/KWh

**R**eliable – 90%+ Capacity Factor
REAL REASONS FOR NUCLEAR POWER?

Economically Compelling - Lowest generated cost among competing fuels @ < 2 cents/KWh

Reliable – 90%+ Capacity Factor

Financial Returns – The Industry “Cash Cow”
**REAL REASONS FOR NUCLEAR POWER?**

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REAL REASONS FOR NUCLEAR POWER?

- **E**conomically **C**ompelling - Lowest generated cost among competing fuels @ < 2 cents/KWh
- **R**eliable – 90%+ Capacity Factor
- **F**inancial **R**eturns – The Industry “Cash Cow”
- **C**onsolidation – Economics of Scale
- **P**olitics – Bush Administration Energy Policy Act 2005 Incentives
  - Protection from cost overruns
  - $1.6¢/KWh production tax credit
  - Federal Loan Guarantees
## REAL REASONS FOR NUCLEAR POWER?

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**REAL REASONS FOR NUCLEAR POWER?**

- **Economically Compelling** - Lowest generated cost among competing fuels @ < 2 cents/KWh
- **Reliable** – 90%+ Capacity Factor
- **Financial Returns** – The Industry “Cash Cow”
- **Consolidation** – Economics of Scale
- **Politics** – Bush Administration Energy Policy Act 2005 Incentives
- **Global Warming** – The Gore Principal
- **Safety** – No incidents since TMI & Chernobyl
OBSTACLES TO FOR NUCLEAR POWER?

PLANT COST ↑ – 3X Coal & 5-7X CCGT ($6,000/Kw)
OBSTACLES TO FOR NUCLEAR POWER?

PLANT COST ↑ – 3X Coal & 5-7X CCGT ($6,000/Kw)

Material Costs – Escalating
OBSTACLES TO FOR NUCLEAR POWER?

- PLANET COST ↑ – 3X Coal & 5-7X CCGT ($6,000/Kw)
- Material Costs – Escalating
- Reactor Prices – No firm pricing
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- \text{Reactor Prices} - \text{No firm pricing}
- \text{ Personnel} - \text{Constraints}
- \text{Fuel Options} - \text{Uranium, coal, gas}
<table>
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<tr>
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</tr>
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</tr>
<tr>
<td><strong>N</strong>uclear <strong>W</strong>aste – Spent fuel options/burial/reprocessing questions</td>
</tr>
</tbody>
</table>
## Advanced Reactor Designs

### U.S. NRC Certified

- Advanced Boiling-Water Reactor (ABWR) GE/Toshiba (1300 MW)
- System 80 Westinghouse (1300 MW)
- AP 600 Westinghouse (600 MW)
- AP1000 Westinghouse (1000 MW)

### U.S. NRC Under Evaluation

- General Electric ESBWR 1390 MW
- Atomic Energy of Canada (AECL) 700 MW
- AREVA (EPR) 1600 MW
- International Reactor Innovative & Secure (IRIS) 335 – 1000 MW
- Pebble Bed Modular Reactor (PBMR) 165 MW
- Gas Turbine-Modular Helium Reactor (GT-MHR)
<table>
<thead>
<tr>
<th>OWNER</th>
<th>PROJECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>TXU Corporation</td>
<td>Comanche Peak – 2x1700 MW (MHI)</td>
</tr>
<tr>
<td>Duke Power</td>
<td>Cherokee County – 2x1100 MW</td>
</tr>
<tr>
<td>Exelon</td>
<td>Clinton Unit 2</td>
</tr>
<tr>
<td>Constellation Energy</td>
<td>AREVA – 2x1600 MW – Unistar Nuclear</td>
</tr>
<tr>
<td>Entergy</td>
<td>Grand Gulf Unit 2 – NuStart Energy</td>
</tr>
<tr>
<td>Fresno Nuclear Energy</td>
<td>Fresno County / Unistar</td>
</tr>
<tr>
<td>Alternate Energy Holdings</td>
<td>Grandview/Bruneau County</td>
</tr>
<tr>
<td>Progress Energy</td>
<td>Levy County – 2x100 MW</td>
</tr>
<tr>
<td>Progress Energy</td>
<td>Harris – 2 x 1100 MW</td>
</tr>
<tr>
<td>NRG Energy</td>
<td>STP 3 &amp; 4 – 2x1350 MW</td>
</tr>
<tr>
<td>Entergy Nuclear</td>
<td>River Bend Unit 2</td>
</tr>
<tr>
<td>PPL Corporation</td>
<td>Susquehanna Unit 3</td>
</tr>
<tr>
<td>FPL Group</td>
<td>Turkey Point – 2x1500 MW</td>
</tr>
<tr>
<td>TVA</td>
<td>Bellefonte – 2x1100 MW NuStart</td>
</tr>
<tr>
<td>Ameren</td>
<td>Calloway Unit 2 - Unistar</td>
</tr>
<tr>
<td>Southern Company</td>
<td>Vogtle Units 3 &amp; 4 – 2x1100MW</td>
</tr>
<tr>
<td>SCE&amp;G</td>
<td>V.C. Summer – 2x1100MW</td>
</tr>
</tbody>
</table>

25 to 30 New Power Reactors Over The Next 15 Years in the U.S.
<table>
<thead>
<tr>
<th>Country</th>
<th>Number of Reactors</th>
<th>Status of Reactor</th>
<th>Constructing</th>
<th>Planned or Ordered</th>
<th>Proposed</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States of America</td>
<td>126</td>
<td>6220</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Russia</td>
<td>58</td>
<td>4320</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Japan</td>
<td>50</td>
<td>47000</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Brazil</td>
<td>2</td>
<td>1140</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>South Korea</td>
<td>39</td>
<td>13900</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>France</td>
<td>30</td>
<td>38000</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Germany</td>
<td>22</td>
<td>37200</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Other Countries</td>
<td>20</td>
<td>34400</td>
<td>1</td>
<td>1</td>
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160 New Power Reactors Over The Next 15 Years
New nuke materials **must** provide.........
New nuke materials *must* provide............

40 – 60 Material Service Life!
New nuke materials **must** provide ..........

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Corrosion Immunity!
New nuke materials *must* provide...........

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Corrosion Immunity!

Low Maintenance!
New nuke materials *must* provide..........

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Low Maintenance!

Support a 90%+ Utility Plant Capacity Factor ($$$$$$)!
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Documented Historical Performance
The Dr.

**HOW MUCH WORLD MARKET TITANIUM MATERIAL AND WHEN ???????**

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<tr>
<th>No Reactors 10-15 Year Build Rate</th>
<th>No Reactors Using Titanium Materials</th>
<th>Total Tonnage Over 10 - 15 Year Period</th>
<th>Annual Ti Purchases Begin 2010-2012</th>
</tr>
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<tbody>
<tr>
<td>160 +</td>
<td>≈ 100 +</td>
<td>38,000</td>
<td>≈ 4000 tons/yr</td>
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Note: Data may be adjusted based on aero build rates.
Take this quiz.....

Match these quotes to the presumptive presidential candidate ??

“I think nuclear power has to be part of our energy solutions”

“I don’t think we can take nuclear power off the table”

“I believe we have to go back to nuclear power”
“You did it, you did it…”
However
A winning Democratic ticket will usher in change that will clearly create a non-friendly nuke environment in Washington. Here are several reasons for this statement.

- Both Obama and H. Reid (Nevada) have issued death threats against the final design certification for the Yucca Mountain dry storage facility. The November electoral votes for Nevada will predictably result in outright cancellation of this facility.

- Gregory Jaczko appears to be the front runner and presumptive appointee to the position of NRC Commissioner no matter what Administration takes power. This twice rejected Chair candidate is clearly anti-nuke and will certainly act as an affront to progress in the COL application process.

- Partisan, pro-nuclear politicians are losing clout in Washington. Senator Pete Domenici is stepping down because of age and health; Senator Larry Craig’s career is “in the toilet” with no pun intended and Senator Craig Thomas has died.
Conclusions….. THE WHY’s & WHY NOT’s of NUCLEAR POWER ??

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Thank you for your attention